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Health and Environmental Effects Profile for 2,4,-DB

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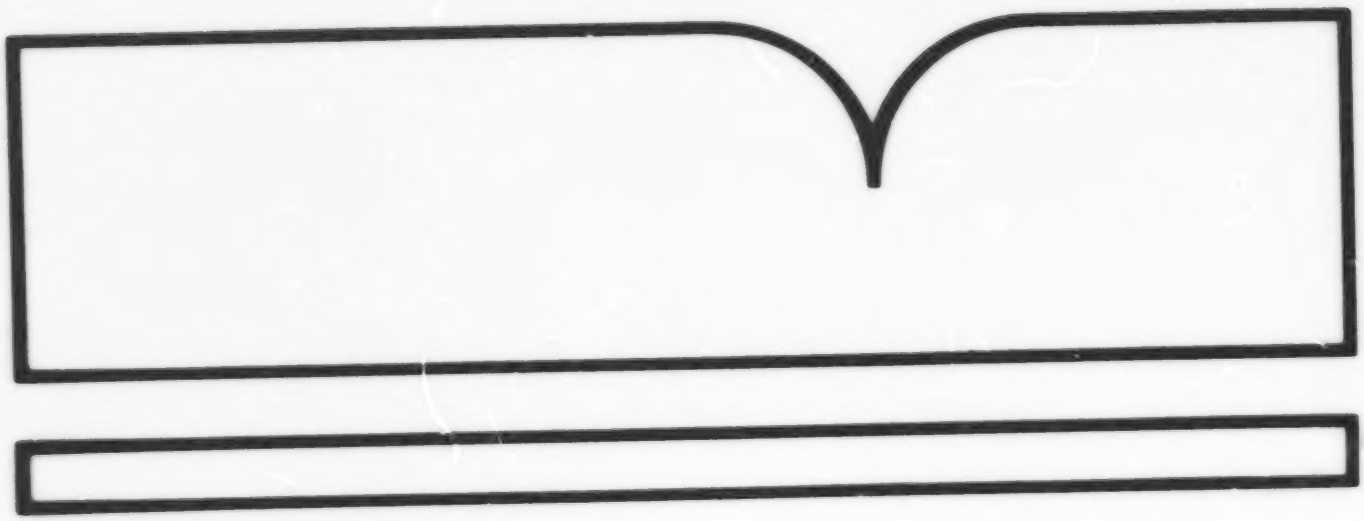

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January 1984

HEALTH AND ENVIRONMENTAL EFFECTS PROFILE FOR 2,4-DB

ENVIRONMENTAL CRITERIA AND ASSESSMENT OFFICE
OFFICE OF HEALTH AND ENVIRONMENTAL ASSESSMENT
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OH 45268

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16. ABSTRACT

The Health and Environmental Effects Profile for 2,4-DB was prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste to support listings of hazardous constituents of a wide range of waste streams under Section 3001 of the Resource Conservation and Recovery Act (RCRA). Both published literature and information obtained from Agency program office files were evaluated as they pertained to potential human health, aquatic life and environmental effects of hazardous waste constituents.

Quantitative estimates have been presented provided sufficient data are available. 2,4-DB has been determined to be a systemic toxicant. An Acceptable Daily Intake (ADI), defined as the amount of a chemical to which humans can be exposed on a daily basis over an extended period of time (usually a lifetime) without suffering a deleterious effect, for 2,4-DB is 8×10^{-3} (mg/kg bw/day) for oral exposure.

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PREFACE

Health and Environmental Effects Profiles (HEEPs) are prepared for the Office of Solid Waste by the Office of Health and Environmental Assessment. The HEEPs are intended to support listings of hazardous constituents of a wide range of waste streams under Section 3001 of the Resource Conservation and Recovery Act (RCRA). Both published literature and information obtained from Agency program office files are evaluated as they pertain to potential human health, aquatic life and environmental effects of hazardous waste constituents. The literature searched and the dates of the searches are included in the section titled "Appendix: Literature Searched."

Quantitative estimates are presented provided sufficient data are available. For systemic toxicants, these include, Acceptable Daily Intakes (ADIs) for chronic exposures. An ADI is defined as the amount of a chemical to which humans can be exposed on a daily basis over an extended period of time (usually a lifetime) without suffering a deleterious effect. In the case of suspected carcinogens, ADIs are not estimated in this document series. Instead, a carcinogenic potency factor or q_1^* is provided. These potency estimates are derived for both oral and inhalation exposures where possible. In addition, unit risk estimates for air and drinking water are presented based on inhalation and oral data, respectively.

The first draft of this document was prepared by Syracuse Research Corporation under EPA Contract No. 68-03-3228. The document was subsequently revised after reviews by staff within the Office of Health and Environmental Assessment: Carcinogen Assessment Group, Reproductive Effects Assessment Group, Exposure Assessment Group, and the Environmental Criteria and Assessment Office in Cincinnati.

The HEEPs will become part of the EPA RCRA docket.

ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

		Page
1.	INTRODUCTION	1
	1.1. STRUCTURE AND CAS NUMBER	1
	1.2. PHYSICAL AND CHEMICAL PROPERTIES	1
	1.3. PRODUCTION DATA	2
	1.4. USE DATA	2
2.	ENVIRONMENTAL FATE AND TRANSPORT PROCESSES	3
3.	EXPOSURE	5
4.	PHARMACOKINETICS	6
5.	EFFECTS	7
	5.1. CARCINOGENICITY	7
	5.2. MUTAGENICITY	7
	5.3. TERATOGENICITY	7
	5.4. OTHER REPRODUCTIVE EFFECTS	8
	5.5. CHRONIC TOXICITY	8
	5.6. OTHER RELEVANT INFORMATION	9
6.	AQUATIC TOXICITY	11
	6.1. ACUTE TOXICITY	11
	6.2. CHRONIC EFFECTS	11
	6.3. PLANT EFFECTS	11
	6.4. RESIDUE	12
	6.5. OTHER RELEVANT INFORMATION	12
7.	EXISTING GUIDELINES AND STANDARDS	13
	7.1. HUMAN	13
	7.2. AQUATIC	13
8.	RISK ASSESSMENT	14
9.	REFERENCES	15
	APPENDIX: LITERATURE SEARCHED	19

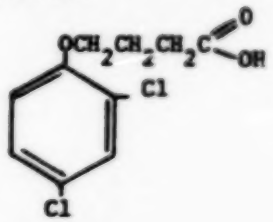
LIST OF ABBREVIATIONS

ADI	Acceptable daily intake
BCF	Bioconcentration factor
DNA	Deoxyribonucleic acid
LC_{50}	Concentration lethal to 50% of recipients
LD_{50}	Dose lethal to 50% of recipients
NOEL	No-observed-effect level
ppm	Parts per million
UV	Ultraviolet

1. INTRODUCTION

1.1. STRUCTURE AND CAS NUMBER

2,4-DB is the common name for 4-(2,4-dichlorophenoxy)butyric acid. It is also known as 4-(2,4-dichlorophenoxy)butanoic acid; γ-(2,4-dichlorophenoxy)butyric acid; butyric acid, 4-(2,4-dichlorophenoxy)-; Butoxon; Butoxone; Butyrac; 4(2,4-DB); 2,4-D Butyric; and Legumex D (NIOSH, 1983). It is usually formulated as a salt or ester of the parent compound (BCPC, 1977). This herbicide was introduced under the code number "MB2878" and trademark "Embutox" by May and Baker, Ltd., in 1957 (BCPC, 1977). The structure of 2,4-DB is given below:



Molecular formula: $C_{10}H_{10}Cl_2O_3$

Molecular weight: 249.1

The Chemical Abstracts Service (CAS) Registry Number for this compound is 94-82-6.

1.2. PHYSICAL AND CHEMICAL PROPERTIES

A colorless, odorless, crystalline solid, 2,4-DB is soluble in acetone, ethanol and diethyl ether. Salts of alkali metals and amines are soluble in water, but hard water precipitates salts of magnesium and calcium. Some of the physical properties of 2,4-DB are given below:

Melting point:	117-119°C (BCPC, 1977)
Water solubility at 25°C:	46 mg/ℓ (BCPC, 1977)
BCF:	71, predicted from water solubility (Kenaga, 1980)
pK_a:	No value located in the available literature
K_{oc}:	530 (Kenaga, 1980)

1.3. PRODUCTION DATA

2,4-DB, a chlorophenoxyalkanoic acid herbicide, is produced by Rhone-Poulenc, Inc., New York, NY, and Union Carbide Corp., St. Joseph, Missouri (SRI, 1983). No production data were available for 1982; however, it was estimated that 2.3 million pounds of 2,4-DB were consumed in 1975 (Ayers et al., 1976). The compound is produced by reacting 2,4-dichlorophenol with butyrolactone (BCPC, 1977).

1.4. USE DATA

2,4-DB is a chlorophenoxy alkanoic acid herbicide possessing plant growth regulating properties. It is used to control weeds in a variety of crops.

2. ENVIRONMENTAL FATE AND TRANSPORT

Pertinent data regarding the fate and transport of 2,4-DB in air could not be located in the available literature (see Appendix). The compound can enter the atmosphere as spray drift and upon volatilization from soil.

The photolysis activity of 2,4-DB is similar, but more selective, than that of 2,4-dichlorophenoxyacetic acid (2,4-D) (BCPC, 1977). Plants that β-oxidize 2,4-DB to 2,4-D are more susceptible to phytotoxic effects than those that are unable to β-oxidize.

Degradation of 2,4-DB by isolated soil microbes and soil has been observed to proceed by β-oxidation of the alkyl side chain or other pathways. The β-oxidation of 2,4-DB by the soil actinomycete, Nocardia opaca and Nocardia coeliaca, has been reported by Webley et al. (1958) and Taylor and Wain (1962). Webley et al. (1958) observed a 20% conversion of 2,4-DB to an unknown 2,4-β-hydroxy acid by N. opaca. Taylor and Wain (1962) reported the liberation of 40 µg/ml phenol in a 48-hour incubation (25°C) containing N. coeliaca and 2,4-DB (0.002 M).

Gutenmann and Lisk (1964) reported the β-oxidation in soil of 2,4-DB to 2,4-D via a 2,4-dichlorophenoxycrotonic acid (2,4-DC) intermediate. Moist silt loam soils incubated at 21°C with 2,4-D were found to convert the compound to 2,4-D with a half-life of 3-4 days. A similar incubation with 2,4-DB resulted in the formation of 2,4-DC, and subsequent formation of 2,4-D after 8 days. The intermediate and final products were determined by gas chromatography and identified with reference compounds having similar retention times. Burger et al. (1962) isolated a Flavobacterium from Honeoye silt loam which grew well in a basal medium containing 0.1% 2,4-DB. An alfalfa root growth bioassay in Dunkirk silt loam was used to estimate the persistence of 2,4-DB. Root growth was 60 and 80% of controls, 27 and

54 days after application (25 ppm), respectively. Smith (1978) reported rapid degradation of 2,4-DB to 2,4-D in heavy clay, clay loam and sand loam soils from Saskatchewan. The substrate, 2,4-DB (2 µg/g) was incubated with the soils at 20°C, and a half-life of <7 days was observed for all soils. After 7 days, 2, 12 and 25% of the applied 2,4-DB was converted to 2,4-D in sandy loam, heavy clay and clay loam, respectively. The compounds were quantified by gas chromatography and identified with compounds having similar retention times.

Smith and Phillips (1976) reported the fungal oxidation of 2,4-DB by Phytophthora megasperma. The isolated fungus was incubated at 22°C with nutrient medium containing 10 ppm of 2,4-DB. About 45% of the 2,4-DB was degraded in 21 days. No 2,4-D was found in the incubation mixture, suggesting that this fungus does not β-oxidize 2,4-DB.

Kenaga (1980) calculated soil sorption coefficients (K_{oc}) and BCFs from data on water solubility for various pesticides. He reported the water solubility of 2,4-DB to be 46 ppm, a K_{oc} of 530 and a BCF of 71 for flowing water systems. A K_{oc} of 530 indicated that 2,4-DB will bind to organic matter and become somewhat immobile. However, the rate of microbial and chemical degradation may change the long-term sorption characteristics.

The fate of 2,4-DB in distilled, sterile and non-sterile lake water was studied by Chau and Thomson (1978). Some degradation of 2,4-DB (4 mg/ℓ) occurred when it was stored for 1 week in natural lake water, but not when stored in distilled or acidified (pH <1 with sulfuric acid) water. These results suggest that hydrolytic degradation in water occurs to a lesser extent than microbial degradation. This experiment was intended as a screening test to optimize preservation of aqueous herbicide samples, so the rate of degradation in natural water was not reported.

3. EXPOSURE

Bovey (1980) and Johnson et al. (1981) have reported on the U.S. Food and Drug Administration "Market Basket" study wherein food products from markets in 25-29 cities were assayed for various contaminants. A 2,4-DB concentration of 0.012 ppm was found in 1 of 360 composite samples (Bovey, 1980) taken between June, 1969 and April, 1970. Johnson et al. (1981) reported the absence of 2,4-DB in samples of adult total diet. Traces of 2,4-DB below the detection limit were found in 2 of 300 adult diet composites sampled during 1965-1966. Samples of dairy products, grain, cereals and sugars have been found to contain 2,4-DB, but very infrequently (Bovey, 1980).

4. PHARMACOKINETICS

Pertinent data regarding the absorption, distribution, metabolism or excretion of 2,4-DB in mammals could not be located in the available literature (see Appendix).

5. EFFECTS

5.1. CARCINOGENICITY

Pertinent data regarding the carcinogenicity of 2,4-DB could not be located in the available literature (see Appendix). It is not scheduled for testing by the National Toxicology Program (NTP, 1983).

5.2. MUTAGENICITY

Andersen et al. (1972) tested 110 herbicides including 2,4-DB for mutagenicity in a modified Ames assay (spot test), using eight unspecified strains of S. typhimurium. 2,4-DB was found to be non-mutagenic using this procedure.

Simmon (1979) tested 2,4-DB for reverse mutations in S. typhimurium strains TA1535, TA1537, TA1538, TA98 and TA100, for induction of mitotic recombination in Saccharomyces cerevisiae D3, for relative toxicity in E. coli strains W3110 and p3478 and Bacillus subtilis strains H17 and M45, and for unscheduled DNA synthesis in human fibroblasts (WI-38). 2,4-DB (5 mg/plate) produced positive results only in the relative toxicity assay, being more toxic to DNA repair-deficient strains p3478 and M45 than to repair-proficient strains W3110 and H17. Negative results were obtained in this assay at exposures of 5.0, 0.1 and 0.01 mg/plate.

5.3. TERATOGENICITY

Courtney (1977) compared the teratogenicity of a number of herbicides in CD-1 mice. 2,4-DB was administered orally in corn oil:acetone (9:1) at a dose of 80 mmole/kg on days 11-13 of pregnancy. Controls were treated in the same manner with the vehicle alone. The dams were killed on day 18 of gestation (day 1 was the day of detection of a vaginal plug). Treatment with 2,4-DB did not affect maternal body weight, but did increase the maternal liver to body weight ratio ($p=0.05$) relative to controls. Among

the litters (9 control and 8 treated litters), there was no effect on fetal mortality or body weight, and no fetuses had cleft palates. The only fetal malformation produced by the other herbicides tested (including 2,4-D and 2,4,5-T) was cleft palate. In an abstract of a Russian study, Sokolova (1976) reported that 2,4-DB, administered orally to pregnant rats, was selectively toxic to the fetus. The threshold dose for fetotoxicity was 0.1 mg/kg and for maternotoxicity (as indicated by an increase in urinary excretion of ascorbic acid) was 3.4 mg/kg. The effects on the fetus were not described.

5.4. OTHER REPRODUCTIVE EFFECTS

Sokolova (1976) reported that oral administration of 2,4-DB at 1 mg/kg "did not affect the function of the testes or ovaries in mature rats". Belova and Sokolova (1971) reported that a dosage of 5.2 mg/kg/day for 200 days adversely affected reproductive function in rats, but a dosage of 3.4 mg/kg/day for 420 days did not. The type or extent of reproductive function affected was not specified.

5.5. CHRONIC AND SUBCHRONIC TOXICITY

Information regarding the effects of subchronic or chronic exposure to 2,4-DB was found only in abstracts of Russian studies. In experiments with the sodium salt of 2,4-DB, Sadovnikova et al. (1966) reported a "slight cumulative effect" in rats following oral administration in a subacute toxicity study. Dermal application of 0.5 g/kg/day to rabbits resulted in skin irritation, reduction in erythrocytes and a decreased hemoglobin concentration. Repeated inhalation of the sodium salt of 2,4-DB as an aerosol (0.08-0.16 mg/ℓ) resulted in irritation of the respiratory tract mucosa in mice. No experimental details were provided.

Belova (1971) administered 2,4-DB orally to rats (5.2-20.8 mg/kg/day) for 350-400 days. Decreased ascorbic acid levels were observed in the liver, spleen, adrenals and brain at all dose levels. At higher doses, a decrease in the concentration of SH-groups (tissues unspecified) was observed. Belova and Sokolova (1971) report a NOEL (for effects on ascorbic acid and SH concentrations) of 3.4 mg/kg/day in rats given 2,4-DB for 420 days.

5.6. OTHER RELEVANT INFORMATION

The available information on the acute toxicity of 2,4-DB is summarized in Table 5-1. Acute exposure to 2,4-DB results in hyperemia of internal organs, hemorrhages in the lungs, pneumonia, dystrophic changes in the brain, and necrosis of the gastric mucosa (Sadovnikova et al., 1966).

TABLE 5-1

Acute Oral Toxicity of 2,4-DB

Species	LD_{50}	Reference
Rat	1.7 g/kg (sodium salt)	Sadovnikova et al., 1966
Rat	2.1 g/kg	Belova, 1971
Rat	0.7 g/kg	BCPC, 1977
Rat	1.5 g/kg (sodium salt)	BCPC, 1977
Mouse	0.5 g/kg (sodium salt)	Sadovnikova et al., 1966
Mouse	0.4 g/kg (sodium salt)	BCPC, 1977

6. AQUATIC TOXICITY

6.1. ACUTE TOXICITY

The acute toxicity of 2,4-DB was determined for bluegill sunfish, Lepomis macrochirus, and largemouth bass, Micropterus salmoides, in two water sources, one having 256.8 mg solids/ℓ and 77.1 mg/ℓ hardness, while the other had 51.8 mg solids/ℓ and 19.0 mg/ℓ hardness (Davis and Hardcastle, 1959). In hard water, the 24-hour LC_{50} value for both sunfish and bass was 10 mg/ℓ. In soft water, the 24- and 48-hour LC_{50} values for sunfish were 20 and 8 mg/ℓ, respectively. Bass were similarly affected, with 24- and 48-hour LC_{50} values of 15 and 10 mg/ℓ, respectively.

The 24-, 48- and 96-hour LC_{50} values for nymphs of the stonefly, Pteronarcys, were 56, 48 and 15 mg 2,4-DB/ℓ, respectively (FWS, 1965).

6.2. CHRONIC EFFECTS

Pertinent data regarding the effects of chronic 2,4-DB exposure on aquatic organisms were not located in the available literature.

6.3. PLANT EFFECTS

The toxic levels of 2,4-DB were determined in several species-strains of algae (Cullimore, 1975). The concentration (range) of 2,4-DB causing a 50% reduction of growth in Haematococcus lacustris strains 34-1b and 34-1j, Hormidium barlowi, and Hormidium flaccidium strains 335-2a and 335-26 were 2-10 and 1-2, 1, and 0.5 and 0.5-1 mg/ℓ, respectively. Several other species, including Chlamydomonas sp., Chlorella sp., Scenedesmus quadricauda, and Mesotaenium caldariorum were not affected by 2,4-DB at concentrations as high as 10 mg/ℓ (Cullimore, 1975).

6.4. RESIDUES

Although 2,4-DB had been used on surrounding watershed regions, Frank and Sirons (1980) reported that no residues were detected in stream water or sediments in Ontario.

6.5. OTHER RELEVANT INFORMATION

Additional data relevant to the toxic effects of 2,4-DB on aquatic organisms were not located in the available literature.

7. EXISTING GUIDELINES AND STANDARDS

7.1. HUMAN

No existing guidelines or standards were located in the available literature.

7.2. AQUATIC

Guidelines and standards for the protection of aquatic organisms from the toxic effects of 2,4-DB were not located in the available literature.

8. RISK ASSESSMENT

No information was available in the published literature on the possible carcinogenicity of 2,4-DB. 2,4-DB has produced negative results in a number of bacterial and mammalian cell culture assays. The only positive results have been obtained in relative toxicity assays using repair-deficient and repair-proficient strains on Escherichia coli and Bacillus subtilis.

The only available published study that reported a NOEL (3.4 mg/kg/day) was that of Belova and Sokolova (1971). This report was published in the Russian literature and was available only as an abstract. The abstract did not provide adequate experimental detail or information on effects for the derivation of an ADI for 2,4-DB.

Statements concerning available literature in this document refer to published, quotable sources and are in no way meant to imply that confidential data, which this document could not address, are not in existence. These data, which are considered Confidential Business Information (CBI), are available in summary form as a CBI Appendix that can be accessed by individuals with appropriate clearance. Conclusions from the CBI Appendix regarding risk assessment can, however, be presented in this document as follows.

The CBI Appendix to this document reviews other animal data from which an ADI of 0.008 mg/kg bw/day or 0.56 mg/day for a 70 kg man can be derived. The ADI was based on a NOAEL of 8 mg/kg bw/day for increased relative liver weight in dogs in a subchronic feeding study and an uncertainty factor of 1000 (10 to account for interspecies extrapolation, 10 for protection of unusually sensitive individuals within the population and 10 for use of a subchronic NOAEL for the derivation of a human ADI).

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APPENDIX

LITERATURE SEARCHED

This profile is based on data identified by computerized literature searches of:

CA SEARCH (Files 308, 309, 310, 311, 320)
TOXLINE
MEDLINE
RTECS
SCI SEARCH
OHM TADS
STORET
SRC Environmental Fate Data Bases
SANSS
AQUIRE

These searches were conducted in May, 1983. In addition, hand searches were made of Chemical Abstracts (Collective Indices 7 and 8th), and the following secondary sources were reviewed:

ACGIH (American Conference of Governmental Industrial Hygienists). 1980. TLVs: Documentation of the Threshold Limit Values. 4th ed. (Includes Supplemental Documentation, 1981). Cincinnati, OH. p. 486.

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